# Rush Pin Fixation Versus Traction and Casting for Femoral Fracture in Children Older than Seven years

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**Background:** The optimal treatment for femoral fractures in children is controversial. The purpose of this study was to compare the results of Rush pin fixation with those of conservative treatment, and to evaluate the sequels of growth plate injury by internal fixation.

**Methods:** Eighteen femoral shaft fractures in 17 children who had concomitant head injury or multiple traumas were treated surgically. The mean age at operation was 9 years 3 months (range, 7 years 5 months to 11 years 1 month). One Rush pin was inserted from the tip of the greater trochanter, without reaming, to fix the fracture. Another 20 age-matched children treated by traction and casting were the control subjects.

**Results:** All the fractures united without consequences. In addition to a decrease in hospital stay with the use of the Rush pin (10 days vs. 27 days, $p<0.05$), fewer leg length discrepancies (4.2 mm vs. 7.1 mm, $p<0.05$) were also noted, compared with conservative treatment. The growth of the proximal femur after Rush pin fixation was evaluated after an average of 59 months. No femur shortening, coxa valgus, or hip dysplasia was noted.

**Conclusions:** Intramedullary Rush pin fixation for femoral shaft fracture in children older than 7 years is a simple and reliable alternative. One narrow and non-reaming pin inserted from greater trochanter did not demonstrate femoral growth inhibition.
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**Key words:**  femur fracture, children, rush pin fixation, growth.

With the potential for rapid union and remodeling in children's bones, excellent results are expected after conservative treatment for pediatric femoral shaft fractures.[1,2] Surgical intervention, however, is indicated in patients with head injuries, multiple traumas, or when prolonged traction and hospital stay is a concern.[3-8] To decrease the period of hospitalization and the time to mobilization, several kinds of fixation devices have been used. Plating is a reliable method, but a large scar and the requirement of a second operation to remove the plate make this technique not favored by all.[9] The extra-skeletal fixator is a good alternative, however, pin tract infection and refractures have been the associated problems.[10-12] The titanium elastic intramedullary nail is theoretically the most ideal implant because it offers stability and avoids epiphyseal plate injury.[13,14] However, the high price of the titanium nail limits its use, and skin irritation over the nail tip is common.[15] Intramedullary nails, such as the Kunstcher nail and

the interlocking nail that require medullary canal reaming, are not widely employed for children because of the potential for injury to the proximal epiphyseal plate and to the blood supply to the femoral head.[16-18] Gonzalez-Herranz et al. reported the growth inhibition on the proximal femur after using Kuntcher nail fixation in 30% of their pediatric patients.[19]

Rush pins have been used as intramedullary devices to stabilize fractures in adults and fragile bones in children with osteogenesis imperfecta.[20-22] Before the popularization of the flexible intramedullary nail, we used Rush pins for femoral shaft fractures in children. This study reviews the results and problems of Rush pin fixation for pediatric femoral fractures, and draws a comparison with the results who underwent conservative treatment.

## METHODS

From 1991 through 2000, 18 femoral shaft fractures in 17 children were treated with antegrade intramedullary Rush pin fixation. The mean age at operation was 9 years 3 months old (range, 7 years 5 months to 11 years 1 month). Twelve patients had associated problems, including head injuries in five, multiple fractures or polytrauma in four, cerebral palsy with frequent seizure attack in one, leg hemangioma preventing traction in one, and failure of previous plating in one patient. The other five patients were enrolled as surgical candidates because the children could not tolerate skeletal traction. One was an open fracture, one was a segmented comminuted fracture, three were fractures with a butterfly fragment, and the others were oblique or transverse fractures.

The femoral fracture was reduced using the closed method. A fracture table was used to apply continuous traction force and to facilitate the operation of the fluoroscopy. A small incision, less than 3 cm in length, was made over the greater trochanter. The diameter of the Rush pin was 1/4 inch or 3/16 inch depending on the diameter of medullary canal. The length was determined by fluoroscopy, leaving the tip above the distal femoral physis. One Rush pin was introduced through the tip of the greater trochanter into the medullary canal without reaming. Caution was taken when the pin tip engaged the medial cortex at the level of the lesser trochanter.

Gentle hammering and rotating of the pin facilitated its advancement without penetrating the cortex. The Rush pin then served as a cantilevel to control the proximal fragment, then the fracture was reduced and fixed by the closed method under fluoroscopy. After the operation, a long leg splint was put in place for 2 weeks for protection. Then, ambulation with crutches was allowed. Patients were discharged on the day after the operation. The Rush pin was scheduled for removal 6 months later (Figs. 1).

Another 20 children, aged between 7 and 11 years (mean, 9 years 1 months), were enrolled as the control (non-surgical) group. The 20 children had isolated femoral shaft fractures treated by skeletal traction and spica casting from 1992 through 1997, and had follow-up examinations for at least 2 years. The age, gender, fracture side, fracture level and fracture comminution were comparable between the surgical and the non-surgical group (Table 1). The length of hospital stay and duration of immobilization by splint or cast were recorded. To document the residual deformity after an adequate period for the remodeling processes, we measured the angulation at the fracture site and the leg length discrepancy by scanogram 2 years after the fracture. The length of hospital stay and the residual leg length discrepancy in the surgical group were compared with the non-surgical group. Statistical analysis was performed using the Student t test for continuous variables and the chi-square test for categorical variables.

## RESULTS

All fractures in the surgical group united smoothly and no re-fractures were noted after removing the pins. No wound infection, avascular necrosis of the femoral head, or back out of the implant occurred in our patients. The mean length of hospital stay in the surgical group was 10 days (range, 1-20 days). Some patients with polytrauma had been stayed in the intensive care unit for several days before the operation. However, the surgical group had a shorter mean hospital stay than the non-surgical group ($10.0 \pm 5.0$ days vs. $23.4 \pm 11.2$ days, $p<0.05$). After discharge, the patients in the surgical group wore one long leg splint for 2 weeks. The patients in the non-surgical group were immobilized in a hip spica cast for $48.7 \pm 8.3$ days, and most of them did not return to school throughout the casting
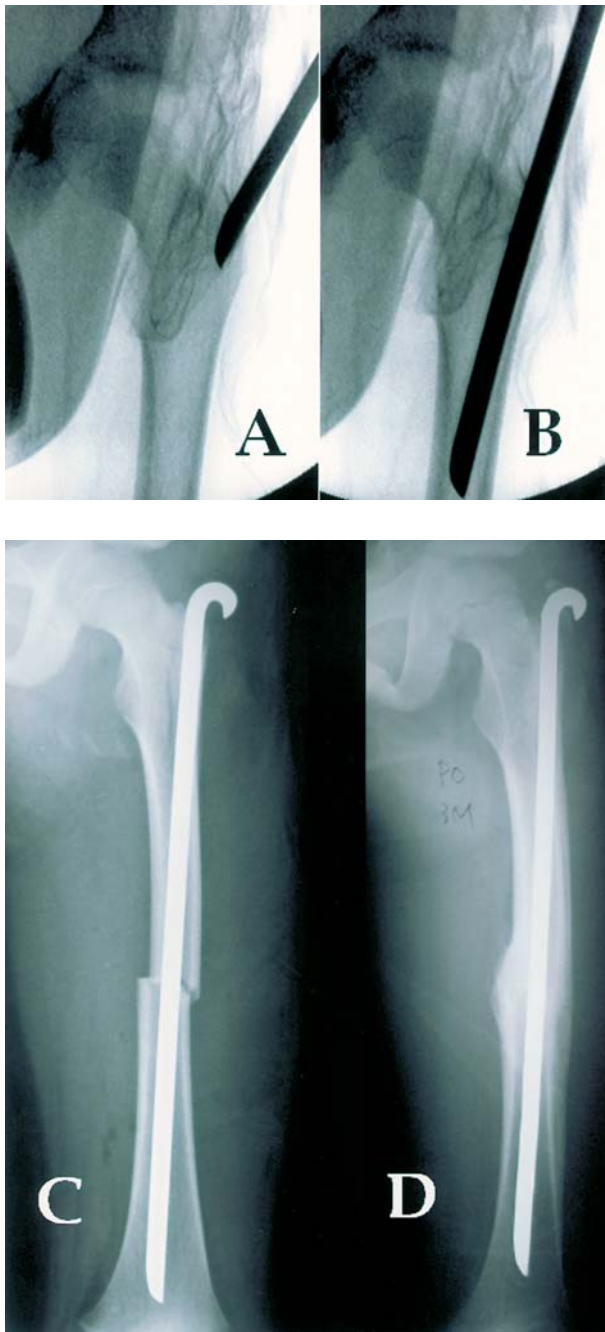
**Figs. 1** (A) One Rush pin was introduced through the tip of greater trochanter without reaming. (B) Caution was taken to avoid penetrating the medial cortex. (C) Femoral shaft fracture fixed with one intramedullary Rush pin. A little angulation or displacement at fracture site was acceptable. (D) Radiograph taken 3 months after operation showed a solid union.

**Table 1.** Patient Data and Results in Surgical Group and Non-surgical Group

|  | Surgical group (17 children) | Non-surgical group (20 children) |  |
|---|---|---|---|
| Average age (range) | 9 years 3 months (7Y5M ~ 11Y1M) | 9 years 1 months (7Y6M ~ 10Y9M) | $p = 0.32$ |
| Gender (M : F) | 11 : 6 | 13 : 7 | $p = 0.98$ |
| Side (right : left) | 6 : 11 | 8 : 12 | $p = 0.77$ |
| Fracture level (proximal: mid: distal) | 2 : 12 : 3 | 5 : 13 : 2 | $p = 0.52$ |
| Comminuted fracture* (yes : no) | 4 : 13 | 4 : 16 | $p = 0.80$ |
| Associated problems† (yes : no) | 12 : 5 | 1 : 19 | $p < 0.05$ |
| **Results** | | | |
| Length of hospital stay | 10.0 days (1 ~ 20 days) | 23.4 days (11 ~ 43 days) | $p < 0.05$ |
| Duration of casting / splinting | 12.1 days (0 ~ 21 days) | 48.7 days (37 ~ 60 days) | $p < 0.05$ |
| Leg length discrepancy | + 4.2 mm (-11 ~ +19 mm) | - 7.1 mm - (-16 ~ +3 mm) | $p < 0.05$ |

* Segmental fracture or fracture with a butterfly fragment
† Problems associated with the femoral fracture included head injury, liver laceration, hemothorax, multiple fracture and pre-existing neuromuscular diseases that complicated the treatment; however, the results in surgical group was better.

period.

Patients in both groups had no limitations in sports activities at the 2-year follow-up examinations. No limping or pain was observed after union of the femoral shaft fracture in the children. The residual angulation at the fracture site after remodeling was less than 10 degrees. These findings demonstrate the high potential of remodeling in pediatric fractures, either treated surgically or conservatively. The leg length discrepancy measured using split scanogram at 2 years after the fracture was $4.2 \pm 5.0$ millimeters longer in the surgical group and $7.1 \pm 7.8$ millimeters shorter in the non-surgical group ($p<0.05$). The numerical difference was significant; however, no functional consequences were observed in either group. The fractured femur in the surgical group was longer than the contralateral side by $5.0 \pm 7.8$ millimeters. Intramedullary fixation through the greater trochanter did not lead to the inhibition of the longitudinal growth of the femur.

The latest follow-up for patients in the surgical group was conducted $59 \pm 12$ months after the operation. No avascular necrosis of the femoral head or deformity at the proximal femur was observed. There

## DISCUSSION

Femoral shaft fractures in children aged between 7 and 11 years have been treated with skeletal traction and spica casts in our center. The Rush pin was used to fix fractures when patients had head injuries or multiple fractures. With the increase in satisfactory results, the surgical indications were extended to patients who could not tolerate skeletal traction or prolonged hospitalization. Current trends in treatment favor surgical stabilization for older children.[3-7,14] Reeve et al. revealed the results of the operations as shorter hospitalization and fewer malunions and delayed unions.[6] Surgery also provided psychological, social, educational, and economic advantages over conservative treatment. In this study, the children in the non-surgical group spent 23.4 days in skeletal traction and another 48.7 days in hip spica casts until the fractures healed. After remodeling for 2 years, leg length was shortened by 7.1 millimeters, on average. Conservative treatment has led to prolonged hospitalization as well as an interruption in school life, and the results are unpredictable. Martinez et al. reported shortening of more than 20 millimeters in 43% of the children who received early spica casting for femoral fracture, and age was a significant factor for unacceptable shortening.[2]

The Rush pin with a diameter of 1/4 inch neither contacts the whole inner cortex at the isthmus, as the Kuntcher nail, nor provides a locking mechanism, as the interlocking nail. The Rush pin offered the effects of internal splinting rather than rigid fixation and superseded the function of skeletal traction. The length of hospital stay for traction was shortened. Immobilization by a hip spica cast is no longer necessary after intramedullary nailing. Children also have the benefit of an early return to school.

The rigid intramedullary nail may injure the blood supply to the femoral head when the nail is introduced from the piriformis fossa.[17-19] Changing the nail entry site to the greater trochanter prevents vascular injury.[23,24] The Rush pin is not as rigid as the Kuntcher nail, so it can be inserted from the greater trochanter to the isthmus without difficulty. Since reaming extends damage to the surrounding epiphyseal plate and vessels, the Rush pin carries less risk of growth disturbance and avascular necrosis than the other nails that require reaming. No avascular necrosis was noted in our patients and the growth inhibition of the greater trochanter was minimal. Galpin et al. found trochanter growth inhibition of more than 1 centimeter in five of 22 patients who
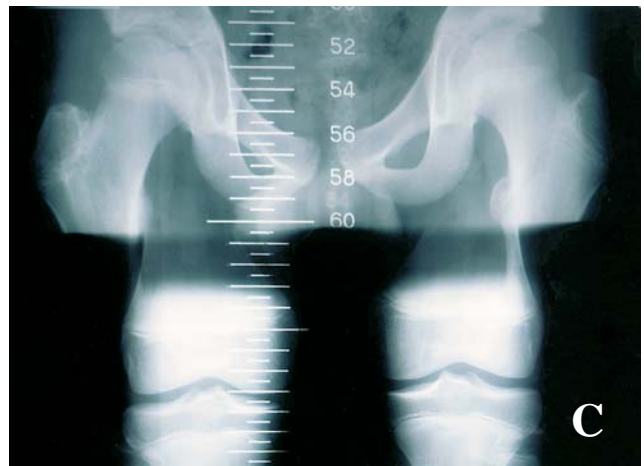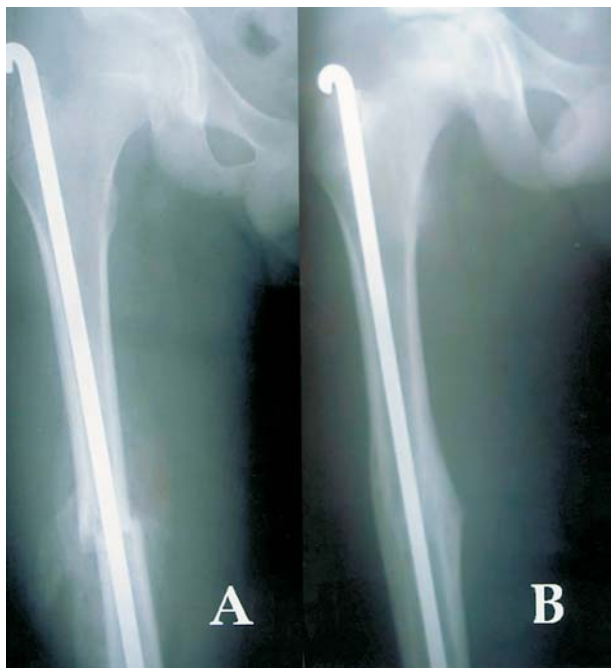


**Figs. 2** (A) Left femoral shaft fracture in a 10 year and 9 month old boy was treated by Rush pin fixation. (B) Radiography taken 1 year after operation. (C) Radiography taken 6 years after operation, no coxa valgus or hip dysplasia.

had undergone reamed nail fixation, and in none of the other 15 patients who had received non-reamed Ender's nails.[16]

Since Rush pin fixation is not rigid, little angulation or translation was observed at the fracture site. However, delayed union or malunion is rarely a problem in pediatric fractures because of the high potential for remodeling. Even if the initial deformity becomes a parental concern; it is less than the deformity after traction and casting. Nevertheless, the Rush pin is unable to maintain femoral length in segmental comminuted fractures. The best indication for Rush pin fixation is transverse fracture with or without butterfly fragments in the middle third of the femur. A case of segmented fracture without cortical contact was managed with skeletal traction first to achieve initial callus formation, then the alignment was stabilized using one Rush pin. The child was free from spica cast immobilization.

Intramedullary nailing is a standard method to treat femoral shaft fracture in adults. It also provides excellent results in older children, except for the risk of injury to growth or the blood supply. One narrow and non-reamed Rush pin inserted from the greater trochanter does not demonstrate vascular injury or femoral growth inhibition in our patients, though the case number in our study is not large enough to have a solid conclusion. Closed reduction, a small wound at the greater trochanter, low technique demand, reliable fixation, and minimal surgical complications make the Rush pin a favorite implant in treating femoral shaft fracture in children older than 7 years.

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# 較大兒童股骨幹骨折的Rush髓內釘治療
# 與牽引及石膏治療的比較

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**背 景**： 對兒童股骨幹骨折的最佳療法仍有諸多爭議，本研究目的爲比較以Rush髓內釘手術治療及傳統保守療法的結果及因骨釘穿透生長板所導致的骨骼發育影響。

**方 法**： 17位股骨骨折合併多重外傷的兒童接受髓內釘手術治療，平均年紀爲9歲3個月大 (7歲5個月至11歲1個月)，股骨骨折以一支Rush釘經由大轉子穿入骨髓腔內固定，其他20位年紀相仿但以保守治療股骨骨折的兒童作爲對照組。

**結 果**： 所有的骨折順利癒合且病童無功能障礙，手術治療病童住院日數較短 (10天，保守療法27天，$p < 0.05$)，且下肢長度差異較小 (4.2 mm，保守療法7.1 mm, $p<0.05$)，骨釘治療平均59個月後，無股骨缺血性壞死或生長遲滯現象。

**結 論**： 以Rush髓內釘固定較大兒童的股骨幹骨折是一種簡單而可靠的治療方式，一支細的髓內釘由大轉子打入股骨腔並沒有發生股骨生長抑制。

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**關鍵字**： 股骨骨折，兒童，髓內釘固定，骨骼發育。